HAWAII GEOTHERMAL PROJECT

GEOTOXICOLOGY (4.1)

SPECIAL REPORT

ENVIRONMENTAL QUALITY STANDARDS:

A COMPILATION FOR GUIDELINE DEVELOPMENT

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1. INTRODUCTION

The prospect of increasing geothermal exploration and power development in Hawaii requires that standards be established for the prevention of environmental degradation and protection of project personnel and local residents against hazardous effluents.

Insofar as can be judged at present, HGP-A has no chemical, environmental or health problems. The longterm consequences of its operation as an experimental electrical power station will provide the real test of its environmental impact, however, after installation of the well-head generator.

The data compiled below are in no way final and only as complete as the currently available sources permit.

2a. ESTABLISHED STANDARDS AND AGENCY-RECOMMENDED VALUES FOR AIR

H_2S

Threshold Limit Value (American Conference of Government and Industrial Hygeinists, 1972)	10 ppm for 8 hrs.
(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977)	10 ppm for 8 hrs.
Shortterm Limit Value (Pennsylvania Dept.of Health, 1965)	20 ppm for 20 min.
(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977)	20 ppm for 5 min.

SO_2

Threshold Limit Value (American Conference of Governmental and Industrial Hygeinists, 1972)	5 ppm for 8 hrs.
(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977)	5 ppm for 8 hrs.
Shortterm Limit Value (Pennsylvania Dept. of Health, 1965)	20 ppm for 20 min.
(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977)	20 ppm for 5 min.
Maximum allowable concentration for 8 hrs. (Federal Occupational Safety and Health Standards)	10 ppm
Maximum allowable concentration for 5 minutes (Federal Occupational Safety and Health Standards)	20 ppm
Alert level	0.3 ppm 24 hr. average

H_2SO_4

Threshold Limit Value

(Registry of the Toxic Effects of Chemical Substances, 1976) 3 $mg \cdot m^{-3}$ for 8 hrs.

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 1 $mg \cdot m^{-3}$ for 8 hrs.

Maximum average

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 3 $mg \cdot m^{-3}$ for 5 min.

NO_2

Threshold Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 5 ppm for 8 hrs.

Shortterm Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 25 ppm for 5 min.

Alert level 0.15 ppm 24 hr. average

CO

Threshold Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 50 ppm for 8 hrs.

Shortterm Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 400 ppm for 15 min.

AsH_3

Threshold Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 0.05 ppm for 8 hrs.

Hg (alkyl)

Threshold Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 10 $ug \cdot m^{-3}$ for 8 hrs.

(National Industrial, Occupational, Safety and Health) 10 $ug \cdot m^{-3}$ 8 hrs

Hg (all forms except alkyl)

Threshold Limit Value

(Hawaii Occupational Safety and Health Standards Act 57, 1972, Revised August 1977) 50 $ug \cdot m^{-3}$ for 8 hrs.

(National Industrial, Occupational, Safety and Health Standards) 50 $ug \cdot m^{-3}$ for 8 hrs.

Ambient Air Quality

(Environmental Protection Agency's recommended 30 day average, Federal Regulations, 1975) 1 $ug \cdot m^{-3}$

Hg (alkyl) continued

Occupational:	(Gertner and Huff, J. Toxicology and Environmental Health 2:491, 1977)	10 $ug \cdot m^{-3}$ maximum allowable concentration for 8 hrs.
Ambient Air Quality:	(Gertner and Huff, J. Toxicology and Environmental Health 2: 491, 1977)	1 $ug \cdot m^{-3}$ maximum allowable concentration for 8 hours
Emission	(Environmental Protection Agency Regulations National Emission Standards 121:0461, 1976)	
	Incineration; wastewater; sludge	1600 gm. per day
	Coal fueled power plants	2700 gm. per day

2b. ESTABLISHED STANDARDS AND AGENCY-RECOMMENDED VALUES FOR WATER

No data pertinent to re-injection have been found. Use is made of State of Hawaii Department of Health Class 2 Water Quality which includes agricultural uses.

pH	(Hawaii Environmental LAws and Regulations Chapter 37A, 1972, revised 1974)	not less than 6.5 nor more than 8.5 units
Total phosphorus	(Hawaii Environmental Laws and Regulations Chapter 37A, 1972, revised 1974)	not over 0.20 mg/1.
Salinity	(Hawaii Environmental Laws and Regulations Chapter 37A, 1972, revised 1974)	no stipulation for other than class AA water
Arsenic	(Community Water Systems, EPA Primary Drinking Water Regulations, 40 CFR 141, June, 1977)	50 ppb
Mercury	(Community Water Systems, EPA Primary Drinking Water Regulations, 40 CFR 141, June, 1977)	2 ppb
	Discharge (Federal Regulation 38,247, Dec. 1973) Into fresh water	20 ppb*
	Into saline water	100 ppb*

*only if low flow in water body is $\geq$10 times flow of waste stream.

3. Environmental Quality Standards

The formulation of environmental quality standards must take into account the baseline condition of the site of perations and its environs. This has not always been possible and often not done, even when the possibility existed.

The geothermal project site located in proximity to a continuously active system of vents, fumeroles and fissures is particularly critical with respect to base line determinations, as such measurements provide the only basis for differentiating the impact of uncontrollable natural processes from the technical operations.

These considerations are based upon a program of sampling and monitoring which began in May 1975 and has involved systematic regular operations at Hawaii Volcano National Park as well as HGP-A. The information obtained in this program is contained in the following reports:

Siegel and Siegel, Geotoxicology (Task 4.1) in: Kamins, R. et al. Environmental Baseline Study for Geothermal Development in Puna, Hawaii. Hawaii Geothermal Project, September, 1977.

Shupe, J., Helsley, C. and Yuen, P. Phase III - Well Testing and Analysis. Hawaii Geothermal Project, January 1, 1977.

Siegel and Siegel, Update of November 1976 Report, Dec. 1976.

Siegel and Siegel, Phase III Report Supplements:
No. 1. Supplemental Remarks, April, 1977.
No. 2. Update of Environmental Sulfur-Gas Measurements. April 1977.
No. 3. Emissions at HGP-A and Natural Vents, July-August 1977, August 1977.
No. 4. Measurements at HGP-A during the Kakalua Eruption of September 1977. September 1977.
No. 5. Aerometry of the February 2, 1978 HGP-A Flashing, February 1978.

4b. Environmental Baselines and changes at HGP-A

On the basis of data collected prior to the first well flashing on 22 July, 1976, and during subsequent shutdown periods the following are representative of the HGP-A area atmosphere composition:

CO	< 0.5 ppm
NO_2	< 0.1 ppm
H_2S	< 0.2 ppm
SO_2	< 0.25 ppm
H_2SO_4	0.25 ug$\cdot$m^{-3}
Hg	$0.8 - 1.0$ ug$\cdot$m^{-3}

During flashing the maximum rise in CO recorded was 1.5 ppm whereas SO_2 and NO_2 showed no change at all, and the highest H_2SO_4 level at any time was 0.25 ug$\cdot$m^{-3}. No arsine (AsH_3) has been detected.

Increases in Hg are independent of well activity, reflecting instead natural thermal emissions. A level of about 1 ug$\cdot$m^{-3} reflects the general atmospheric norm, but East Rift activity can elevate this figure 10-fold at HGP-A but 50-200 fold on the Kilauea East Rift.

The plume itself as a fixed emission site yields 1 g$\cdot$24 hr^{-1} of total mercury.

Well head and weir box H_2S measurements yield maximum values of 5.5 - 7 in ground steam but decrease to ca 1 ppm during operation. The plume itself during even 15-30 min. continuous operation yields, at 10 m from discharge point, 0.7-3.1 ppm. At 100 m. downwind, the plume falls to a figure of less than 0.1 ppm.

During drilling and early well testing operation, well waters yielded relatively large amounts of HgS particulates, but during flow tests since the July 22 flashing, maximum Hg levels of 1 - 1.5 $\mu g \cdot l^{-1}$ were found. These frequently dropped during flow to levels of < 0.2 $\mu g \cdot l^{-1}$.

With respect to environmental impact, reference may also be made to the Final Report -- Hawaii Geothermal Project Complaints Concerning Drinking Water, etc. addressed to the District Health Officer, Hawaii, from Chief Sanitarian, Hawaii District, dated 12 May, 1977 at Hilo. Analyses of water showed no detectable H_2S, sulfate, arsenic or mercury even only 0.5 miles from the wellhead.

4c. Recommendations

Compliances:

1. CO, NO_2, SO_2, H_2SO_4, and arsenic all fall within existing Ambient Air Quality or occupational limits, as appropriate.

2. H_2S falls well under existing limits with possible exception of approaches to occupational limits during well starting.

3. Hg levels at HGP-A approximate EPA recommended ambient air levels of 1 $\mu g \cdot l^{-1}$ but this is a characteristic feature of the air mass subject to natural geothermal influence and not well activity. This level does not have the force of a regulation, however, and well Hg output and impact on air quality fall within existing standards.

4. The geothermal well discharge waters as class 2 waters are in compliance with all standards given above.

Exceptions:

1. During periods of unusual fumarolic activity or eruptions the rise of H_2S, SO_2, H_2SO_4, Hg and possible CO are characteristic and well documented. These gases, subject to wind and weather, can be transported widely over the Hawaiian Islands, the Puna District in general and HGP-A in particular included. During such active phases, it may not be possible for HGP-A to remain in compliance with one or several environmental quality standards. Such non-compliances should be noted without prejudice as a consequence of nature. It follows that the validity of this exception depends upon continued sampling and monitoring at Kileuea, the rift zones and other natural thermal sites.

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HGP-A Geothermal Generator Project

Construction and test activities at the geothermal site in Puna were recently concluded with the successful completion on the 18th of January of 16 days of continuous flowing of the well and gathering of engineering and chemistry data.

The equipment now installed at the site is required for two main purposes: to obtain engineering data to confirm the design requirements for the Turbine Generator and Condensing equipment and to evaluate the design of the noise suppression and odor removal equipment.

The engineering data obtained during the test indicates that the geothermal steam pressure, temperature and flow rate are adequate to produce the 3 megawatts (3,000 kilowatts) of electricity for which the power plant is designed. The geothermal steam flow rate is 60,000 lb/hr at 160 psig and 350°F. There are no indications that recasing the well last October had any adverse effect on the well's performance.

The odor abatement system proved so effective in removing hydrogen sulfide that only 20-25% of the originally estimated quantity of chemicals was required. The process uses a caustic soda solution and hydrogen peroxide which are injected into the steam to reduce the hydrogen sulfide to a non-odorous sulfur compound. Although the chemical processes are well known, the HGP-A well is the first to treat the total steam flow from a geothermal well in this manner. The process removed 97% of the hydrogen sulfide which is well within the plant's design requirements. An independent assessment conducted by Lawrence Livermore Laboratory confirmed the effectiveness of the abatement process. The management and staff of Brewer Chemical and FMC provided valuable technical

guidance and support in the use and handling of the chemicals used in the experiment.

The primary source of noise in previous tests was the venting of the steam to the atmosphere. During the latest test, noise was suppressed by piping the steam to a concrete chamber below grade and then exhausting through a rock and cinder muffler to the atmosphere. Another major source of noise is the high pitched sound that eminates from the steam flow control valves. To suppress this noise the HGP-A flow control valve was installed in another concrete chamber also below grade that was lined with high temperature acoustical material. The net result of these efforts reduced the noise to 60 decibels at the fence and essentially undetectable 1/2 mile away. The design requirement for the plant is 65 decibels at 1/2 mile.

During the severe storm that hit the Islands the HGP-A well site suffered numerous and long power outages. During these periods it was not always possible to chemically treat the steam to remove hydrogen sulfide or to operate the equipment in the normal noise suppression mode. However, there was sufficient standby power that allowed the operators to keep from shutting down the well. The final power plant will have adequate standby power for noise and odor suppression in the event of power outages.

Although the primary objectives of the test were met other valuable engineering data were obtained that will assist in improving the performance of the power plant when it is completed. The construction work, equipment and test operations were undertaken at a total cost of approximately $800,000 with $320,000 of the cost going for noise and odor abatement. The next phase of activities which is expected to start in February include site work, construction of the Turbine Generator Building and installation of an 8" water main.

The test was directed by Rogers Engineering of San Francisco who is designing the power plant. They were supported by University of Hawaii engineers and geochemists. The HGP-A Geothermal Generator Project is managed by the Research Corporation of the University of Hawaii on behalf of the U.S. Department of Energy and the HGP-A Development Group which is chaired by Hideto Kono, Director of the State Department of Planning and Economic Development.

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